AQUIFER HYDRAULICS

The location and depth of plentiful shallow ground-water supplies in Will and southern Cook Counties is dictated by the layering of geologic materials with high and low permeabilities. The uppermost aquifers, or high-permeability units, are contained in the glacial sand-and-gravel deposits (figures 6 and 7). Water entering these aquifers generally passes through a low-permeability aquitard formed by clay-rich till in the surficial layer of undifferentiated drift (figure 5). In the sand aquifers, ground water flows either laterally towards discharge areas or downwards towards the next aquifer in the Silurian dolomite.

Water enters the Silurian dolomite aquifer from the sand-and-gravel aquifers either directly or through more drift with low permeability. A small amount of water may also enter the aquifer directly from bedrock outcrops in recharge areas, such as the ones shown in plate III in Bloom Township (T35N, R14-15E). Most of the ground water in the Silurian dolomite aquifer moves laterally towards discharge areas along rivers or to production wells, although a small amount of water leaks downward through the Maquoketa Shale aquitard and into the Cambrian-Ordovician aquifer. Walton (1965) estimated the flow rate through the Maquoketa Shale to be a very low 2,100 gallons per day per square mile (gpd/mi^2).

Occurrence of Ground Water in the Silurian Dolomite Aquifer

Ground water in the Silurian dolomite aquifer occurs in cavities formed by the chemical dissolution of the rock along horizontal bedding plains and vertical stress fractures. The ability of water to flow through these cavities is known as the "secondary permeability." The primary permeability of the rock matrix is so low that it does not contribute to the overall productivity of the aquifer, although it is high enough to play an important role in the sorption of contaminants moving through the fractures and bedding planes.

The major water-bearing cavities formed in the vertical fractures are characteristically hundreds of feet long, while the width decreases from a few inches at the top of the dolomite to almost nothing at the bottom. These enlarged fractures are generally subparallel with spacings that range from a few feet to tens of feet wide. They are typically interconnected with smaller fractures that have more random orientations. A water-supply well fortunate enough to intersect a significantly enlarged vertical fracture will usually have a high capacity. However, a well located a few feet away from the fracture may be unusable for a supply unless there is significant dissolution along the horizontal bedding planes.

The frequency and size of the water-bearing openings is greatest at the top of the dolomite where preglacial weathering was greater. Historic preglacial water levels were below the top of the dolomite. This allowed carbonic acid formed from dissolved carbon dioxide and organic matter to penetrate into the rock and cause dissolution along fractures and bedding planes. The greater the depth to water, the deeper the dissolution occurred and the greater the resulting secondary permeability. As a general rule in designing and operating municipal well fields, it is very important to keep static water levels above the top of the bedrock. When the water level falls below the top of the dolomite aquifer and dewatering begins, many of the larger dissolution cavities near the top of the aquifer will no longer contribute water to the well, causing the production capacity to drop off and drawdown to increase greatly.

By reviewing tests of specific capacity (discharge per foot of drawdown) for nearly 800 wells in northern Illinois, Csallany and Walton (1963) examined the relationship in well productivities versus different geologic factors. The specific-capacity values used for these comparisons ranged over two to three orders of magnitude, and the differences for each comparison are quite discernible. Results of the study show that the specific capacities of wells located on bedrock uplands are three to four times higher than for wells located in bedrock valleys. A similar study in Chicago Heights by Prickett et al. (1964) also showed that given an equal saturated thickness, the specific-capacity values for wells in areas of partial dewatering are three to four times less than the values for wells outside these areas.

Overlying glacial materials contribute to the specific capacity of a well by providing extra water, or leakage, through the openings in the top surface of the dolomite. Csallany and Walton (1963) found that wells in portions of the aquifer overlain by sand and gravel have a specific capacity three to four times higher than wells in portions overlain by till. The data also show that the thickness of the sand and gravel is not a factor for wells with high specific capacity. However, as the lower end of the specific-capacity distribution is approached, areas with less than 10 feet of overlying sand and gravel become progressively less productive than areas with more than 10 feet.

Hydraulic Properties of the Silurian Dolomite Aquifer

Two hydraulic properties, transmissivity and storage, are used as quantitative measures of permeability and yield of an aquifer and are essential for determining the economic usefulness of a particular well or aquifer. Transmissivity (T), the ability of an aquifer to transmit water, is defined as the rate of flow through a unit width of the aquifer under a unit hydraulic gradient. In common units, transmissivity is expressed as